

Towards a consensual method to assess climate change impacts from bio-based systems

BENOIST Anthony¹, CORNILLIER Claire²

¹ CIRAD, BioWooEB research unit, ELSA research group, TA B-114/16, 73 rue Jean-François Breton, 34398 Montpellier Cedex 5, France

² FCBA, Environment & Health Department, allée de Boutaut, BP 227, 33028 Bordeaux Cedex, France
E-mail contact: anthony.benoist@cirad.fr

1. Introduction

Current literature shows increasing concerns over the assessment of climate change impacts from bio-based systems [1]. This generally includes carbon neutrality assumption for biogenic carbon emissions, modification of carbon stocks in soils and biomass due to changes in land uses or in land management practices, and valuation of temporary carbon storage in long-lived bio-based products. These challenges raise the broader issue of climate change impact assessments of systems involving compartments of the biogenic carbon cycle. Should biogenic carbon emissions be accounted for as if they were fossil emissions? if not, how should they be differentiated from one another? What are the actual climate change impacts of variations in carbon stocks?

For the time being, there are no consensual answers to these questions within the scientific community. Different characterisation models have been proposed and used in the literature. These models were generally developed in different contexts and were based on different underlying principles, generating significant methodological disparities. This work aimed at identifying best available approaches to deal with climate change specificities of the biogenic carbon cycle, in order to develop a more consensual method.

2. Materials and methods

A critical review of existing methods was carried out to identify their main strengths and weaknesses. Seven methods were identified and considered in this review:

- Five methods dealing with GreenHouse Gas (GHG) emissions: conventional Global Warming Potentials (GWP) from IPCC according to a carbon neutrality approach; conventional GWP from IPCC according to a full accounting approach; time-adjusted GWP [2,3]; biogenic GWP [4]; and biogenic accounting factors [5]; and
- Two methods dealing with land occupation and/or transformation: ILCD / IPCC recommendation to account for carbon stock changes from land transformation [6]; and Müller-Wenk proposal adopted in the land use framework [7,8].

The critical review consisted of eight criteria divided into four main categories:

- Completeness in terms of environmental mechanisms covered (GHG emissions, variations in carbon sequestration potential from land transformation and from land occupation);
- Scientific soundness, including validity of general principles of the method, quality of underlying calculations, and international acceptance;
- Genericity, in terms of application context and modelling approach - attributional or consequential;
- Easiness of use, considering challenges for collecting LCI data and for generating new Characterisation Factors (CF).

Ratings of the different methods according to these criteria are summarized into Table 1.

3. Results and discussion

The 'International acceptance' criterion showed that the most consensual characterisation models are currently the full accounting approach for GHG emissions, and ILCD / IPCC recommendation for land use transformations. However the combination of these methods fails to reflect the dynamic nature of the biogenic carbon cycle (see 'General principles' criterion). Several methods were developed to overcome this issue and bring a more dynamic assessment of climate change impacts from bio-based systems: time-adjusted GWP, biogenic GWP, biogenic accounting factors, and Müller-Wenk proposal.

		GHG emissions					Land use	
		Carbon neutrality	Full accounting	Time-adjusted GWP	Biogenic GWP	Biogenic accounting factors	ILCD / IPCC recommendation	Müller-Wenk proposal
Completeness		3	4	4	1	1	3	4
Scientific soundness	<i>General principles</i>	2	3	4	4	2	3	4
	<i>Underlying calculations</i>	N/A	N/A	4	1	2	N/A	1
	<i>International acceptance</i>	1	4	3	3	2	4	2
Genericity	<i>Application context</i>	2	2	5	4	2	2	4
	<i>Modelling approach</i>	3	3	3	2	4	3	3
Easiness of use	<i>Collecting LCI data</i>	5	4	1	4	2	3	5
	<i>Generating new CF</i>	N/A	N/A	N/A	1	2	4	3

1 2 3 4 5 : Criterion rating scale, from 1 (weak) to 5 (strong).

Table 1: Summary of existing method ratings for the different criteria of the critical review

These dynamic methods are still in their infancy and present many gaps to be fully implemented. Among the methods considered in this review, time-adjusted GWP and Müller-Wenk proposal were identified as the most promising ones due mainly to the scientific soundness of the former, the easiness of use of the latter, and the good genericity of both methods. Based on this finding, a new method that benefits from the advantages of these two methods is proposed. As Müller-Wenk proposal, this method relies on the land use framework related to carbon sequestration potential with the time-adjusted GWP embedded to better reflect the dynamics and reversibility of the biogenic carbon cycle.

4. Conclusions

Based on a critical review of literature to assess climate change impacts from bio-based systems, a new method combining the advantages of the most promising existing approaches has been developed. This method is able to assess climate change impacts from land use. It complies with the general land use framework. It is compatible with full accounting approach for GHG emissions and temporary carbon storage valuation. It also remains sufficiently practicable. Main perspectives for further work are related to the need to better take into account the dynamic nature of the climate system, which is insufficiently considered in existing characterisation models.

5. References

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Acknowledgement - The authors wish to thank ADEME (French Environment and Energy Management Agency) for its financial support, and especially Alice GUEUDET and Miriam BUITRAGO for their valuable comments.